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chemical gypsies

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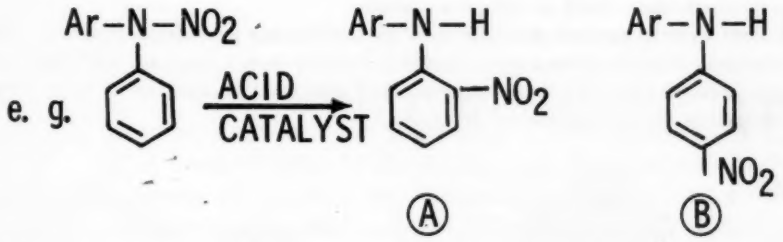
The makers of materials employ a variety of general methods to achieve their goals of preparation of specific compounds: addition of one species to another, condensation of two species to form one, reaction of two species to form product and by-product, rearrangement of one structural form to another, etc. This last method of rearrangement is most curious and chemists continually seek to learn exactly how the migrations of atoms or groups of atoms occur in these transformations. By what pathway do they wander from one site to another, and how can we manage to control and influence these chemical gypsies?

A specific rearrangement which has been under study for many years is known as the Nitramine Rearrangement:



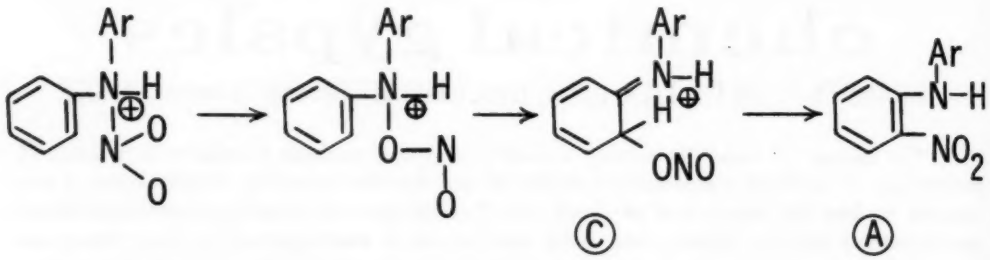
Its existence was known as far back as 1893 but not until recently have some important details come to light which allowed several mechanisms to be proposed. Finally, it remained for Dr. E. D. Hughes of University College, London, under AFOSR support, to achieve some delineation among the alternative pathways.

The first necessity was to decide between an inter- and intra-molecular mechanism (i.e. Does the nitro group wander between different molecules or does it stay close at home to the

molecule it started from.) Clearly this can be done if one can identify the nitro group in some way. For this Hughes used an isotope of nitrogen (–N^{15}, the usual nitorgen is N^{14}) and introduced it into the reaction mixture as extra and free $N^{15}O_2$ anions. When none of these showed up in the (A) products, he knew the path had to be intramolecular. Had the $N^{14}O_2$ ever left the parent molecule, it would have to fight the $N^{15}O_2$ to get back and so some product would necessarily contain $N^{15}O_2$. In the (B) products a certain amount of mixing of N^{14} and N^{15} was observed and so (A) and (B) appear to arise, at least in part, by two different paths.

Thereafter, he studied the effects of the acid catalyst, varying it in regard to type and strength. Also he investigated labeling of certain positions of the benzene ring with deuterium, an isotope of the hydrogen which normally is there. C-D bonds break less rapidly than do C-H bonds and so studying the rates of reaction proved valuable. A decrease in rate, everything else being equal, means that a C-D bond is being broken instead of the usual C-H bond.

Interpretation of the results of the above critical experiments lead to the following conclusions. First the starting nitramine reacts rapidly and reversibly (i.e. it reacts and "unreacts" back to starting material) with the acid. From there on the paths leading to (A) and (B) differ. To get (A), first the nitrogen and an oxygen change places



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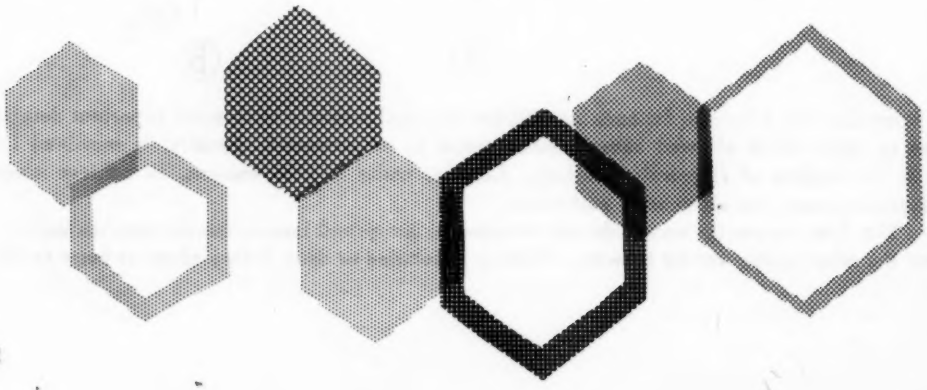
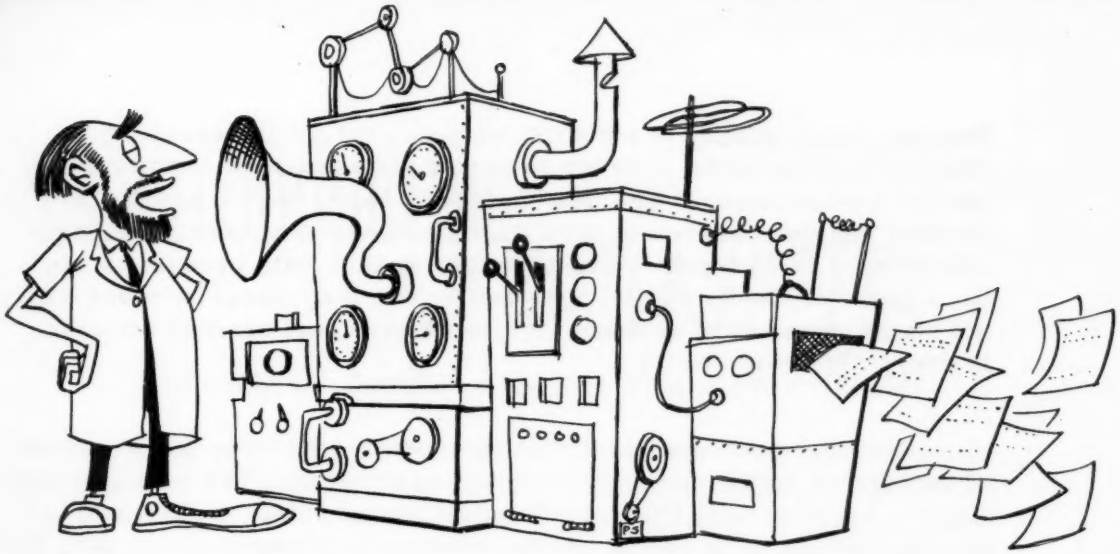
then one oxygen attaches itself to carbon and finally N and 0 again change places. Never has the NO_2 group left its molecule! To get (B) though, two paths must be considered: one in which the intermediate (C) has one of its oxygen attach itself to the para carbon, that one completely across the ring from the NH_2, and one in which the NO_2 becomes free of the molecule and then later attaches itself on the para carbon.

Clearly more work is needed. But this work by Hughes has provided a firm foundation of two pathways which other chemists need to ponder. Here we now know more than just starting point and end product. We know the route between. And knowing this enables us to prepare new and specific materials with a minimum of difficulty.





NEW SPEECH RESEARCH FACILITY

Communications Sciences Laboratory (AFCRL)

AFCRL has placed in operation a new facility for speech signal analysis and synthesis. This new facility is being used to investigate ways to transmit voice signals over extremely narrow band channels while preserving to the greatest possible extent natural voice quality and intelligibility. The transmission of speech signals with greater reliability and security is another aspect of the AFCRL speech research program.

With the new facility, AFCRL is investigating the spectral patterns of words and individual syllables in the most minute detail. Words can be "stretched out" to twelve times their normal length, and any desired segment or segments of the speech can be examined to see how it contributes to listening quality and intelligibility. The pitch component of speech can be analyzed and numerical values of inflection patterns printed out on a flexowriter in detail; synthetic pitch of any desired frequency may be substituted to determine the optimum voice inflection from the standpoint of intelligibility and naturalness.

The primary elements of the speech facility are a vocoder, a special speech data processor, and a noise-free listener's studio.

Because voice quality is a subjective judgment, it is necessary to conduct listener tests in order to arrive at optimum parameters for speech transmission. The new facility is based on the results of several year's research by AFCRL scientists. This early research led directly to the specifications for the speech data processor, and for a new Polymodal Digital Vocoder. (The Polymodal Vocoder will not be delivered until January 1963; a conventional channel vocoder is presently being used.)

Vocoders are used to divide the speech spectrum into a number of contiguous bands by a bank of band pass filters. The output of these filters, together with the talker's pitch fundamental, is digitized and transmitted as digital data. At the receiver another vocoder uses this digital information to reconstruct the speech signal. The signal is then reproduced by means of a voice synthesizer. Voice quality is dependent upon the transmission rate of the system. The new Polymodal Vocoder will differ from conventional vocoders in that several transmission rates will be possible, ranging from 1200 bits to 9600 bits per second, permitting a user to match the data rate to the available channel.

For the past several years, AFCRL scientists have investigated the derivation of a basic set of voice patterns which might represent all the acoustic components of speech sounds. With a set of about 4000 such basic patterns, it will suffice to transmit only digital information representing these patterns, rather than the more complex set of digits needed for each voice sound. The speech data processor has as one purpose the analysis of the voices of many individual speakers and deriving from these voices a basic set of speech patterns that can be stored in a magnetic drum. Once the basic set of speech pattern modes are established, any talker's voice patterns can be converted for digital transmission by matching them against the stored patterns.

As channel capacity -- or bit rate -- is reduced, the natural quality of the voice decreases. AFCRL hopes to arrive at a flexible digital voice transmission system that will permit the Air Force user a choice of a number of alternate data rates ranging from a high fidelity voice channel, to an extremely narrow band channel to be used in those situations where voice must be transmitted over very great distances and available channel capacity is limited.

superconducting MAGNETS

LT. COL. RALPH W. CONNERS, Solid State Sciences Division (AFOSR)

The National Magnet Laboratory, operated by the Massachusetts Institute of Technology under Air Force Office of Scientific Research sponsorship, recently discussed why certain superconducting alloys, for magnetic applications, do not produce anywhere near the theoretical field strength.

A mechanism of induced persistent currents is offered to explain the low current carrying capacity of Nb-Zr solenoids. The persistent currents are induced as the magnet is energized and are of sufficient magnitude to saturate the superconducting filaments. The magnitude of the induced currents can be estimated from a measurement of the residual field in the solenoid.

The current carrying capacity of Nb-Zr solenoids is shown to be a particular function of field, inside diameter, and geometry. The most important conclusion drawn is that to generate fields in large bore magnets will require considerably more wire than would be predicted from considerations neglecting the induced currents.

The measured axial field profile of a Nb-Zr solenoid does not deviate significantly from a calculated profile based on normal conductors. However, the residual field, measured after the magnet current has been reduced to 0, amounts to approximately 2% of the maximum main field. This residual field is evidence of the existence of persistent currents other than those of the main series current in the magnet. Residual fields of 2% can also be found in niobium coils, and most probably in coils made of other superconductors.

As the field is increased, local currents are generated which attempt to reduce the changing field and attempt to prevent flux from penetrating the windings. The local currents concentrate at the ends of the solenoid where the fringing field is greatest. Fig. 1 is a schematic presentation of the persistent eddy-currents that might be set up in a length of wire. These eddys can be treated as dipoles distributed in some fashion throughout the coil.

It would be impossible to infer the exact distribution and magnitude of the dipole currents from a single axial profile measurement.

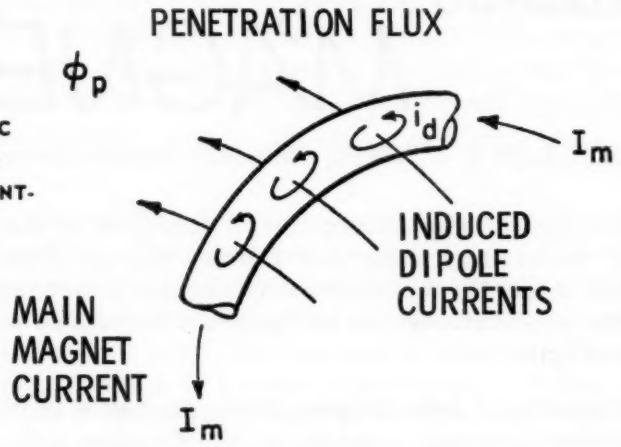


FIG. 1 SCHEMATIC PRESENTATION OF INDUCED PERSISTENT-EDDY-CURRENTS.

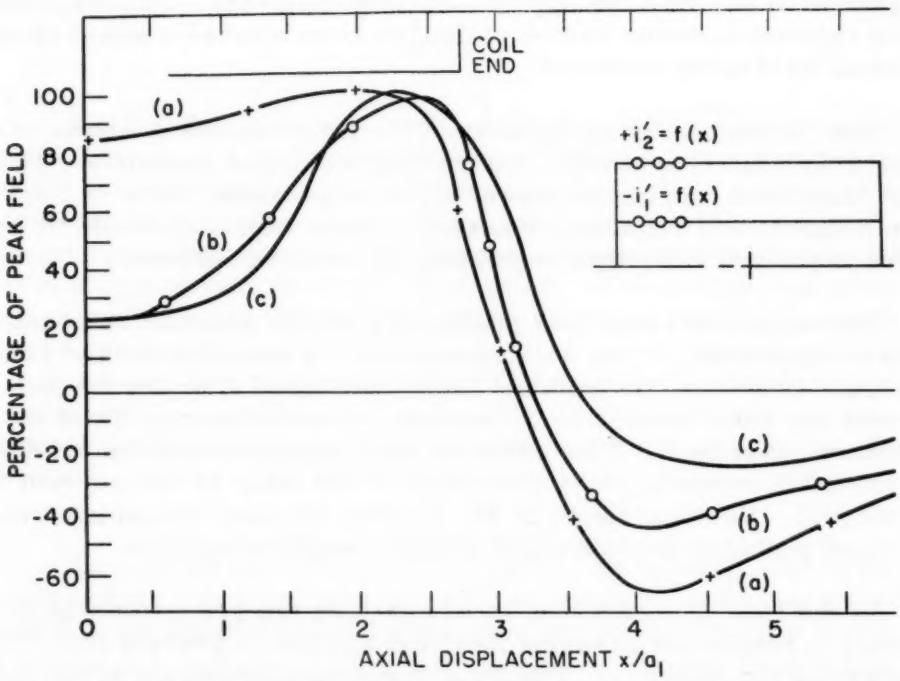


FIG. 2 COMPARISON OF MEASURED AND CALCULATED RESIDUAL FIELDS.

FIG. 2b FIELD PROFILE FROM TWO NON-UNIFORM CURRENT SHEETS $i_1' = -i_2' = a + bx^2$

FIG. 2c MEASURED FIELD PROFILE.

However, we can make several different reasonable assumptions and obtain an order of magnitude of the maximum circulating currents.

1. If we assume a uniform distribution of dipoles throughout the volume parallel to the axis, the magnitude of the equivalent current sheets to produce the profile shown in Fig. 2b would have to be 930 ampere-turns per centimeter. With insulated .010 inch wire I_d would be 31 amperes.

2. If we assume a non-uniform but parallel distribution of dipoles, the magnitude of the peak current necessary to produce the profile shown in Fig. 2c would be 35 amperes.

3. If we assume a uniform but non-parallel distribution, where each dipole is magnitized in the "optimum" direction to produce the maximum central field, we would require roughly one quarter of the currents of (1) and (2) above.

We would expect the actual currents to be between these extremes.

POSSIBLE DIRECTIONS FOR IMPROVEMENT OF THE CURRENT CARRYING CAPACITY

1. The use of non-superconducting coils at the superconducting solenoid ends to spread out the flux and reduce the induced currents at the solenoid corners.

2. The use of Nb_3Sn coils at the ends of the Nb-Zr solenoid.

3. The use of an iron return circuit to channel the flux away from the coil ends.

4. The use of a tapered coil form to reduce the normal component of the field at the inner boundary.

5. The use of short pancake coils.

6. The use of greater spacing between turns.

7. The use of a toroidal winding.

PRESSURE EFFECTS ON semiconductors

CAPT. CARL B. HILLAND, Solid State Physics Research Laboratory (ARL)

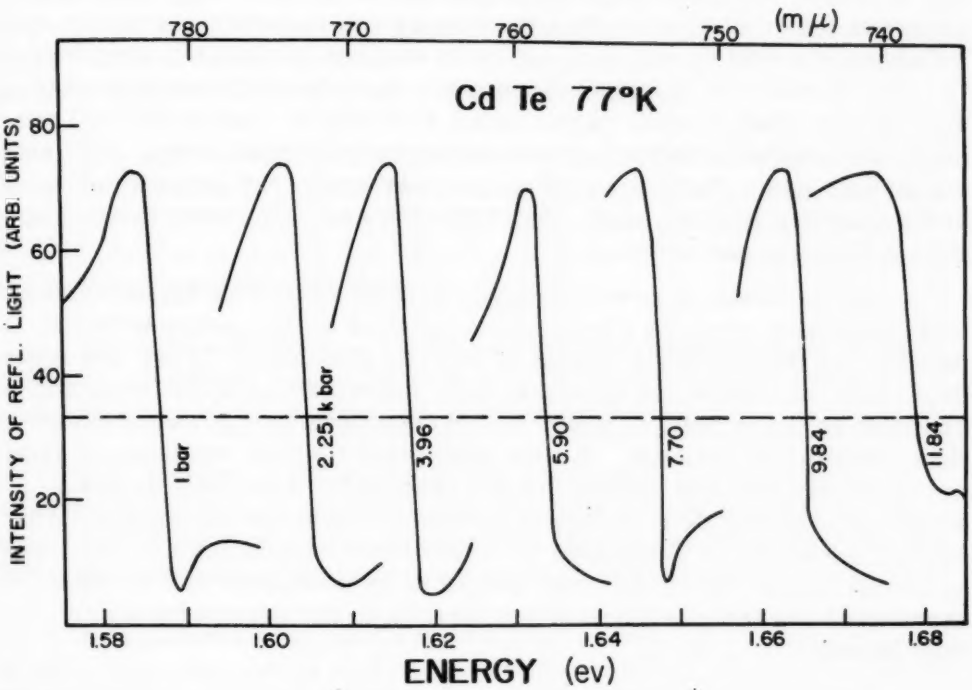
One way of investigating the energy band structure of a semiconductor is to observe the effects of pressure on its optical and electrical properties.

Under the supervision of Dr. Dietrich Langer of ARL, research at high hydrostatic pressures has been directed toward a study of pressure effects on various II-VI compounds. These are; CdS, CdTe, and ZnTe the last of which is still undergoing investigation at the present time.

The hydrostatic pressures needed to produce measurable effects in solid materials are quite high and technological problems exist not only in producing these pressures on the sample but also in making meaningful measurements under pressure. Equipment now in use consists of a hydraulically-operated liquid pressure generator which uses pentane as a working fluid and a hydraulically-operated gas pressure generator which uses helium as a working fluid. Both of these generators were designed and built at ARL. Each has the capability of exerting a hydrostatic pressure of about 18,000 atmospheres.

In general, optical experiments are set up to measure a reflected, emitted, or transmitted light through wide ranges of pressure and temperature. The sample is placed in a steel pressure vessel which is connected to the pressure generator through a capillary tube of stainless steel. The pressure vessel contains sapphire windows which provide a light path to and from the sample. Throughout the experiment, the temperature is carefully controlled by immersing the pressure vessel in a cold liquid, normally liquid nitrogen. An analysis of the pressure dependence of the reflection, emission, or transmission spectrum of the crystal provides useful information regarding the characteristic energy levels which exist in the crystal. For example, observations by Langer of the shift of emission lines of CdS with pressure indicate that the energy levels of the centers responsible for the emission, shift in unison with that of the known minimum of the conduction band. Reflection measurements for CdTe under pressure have shown peaks near 1.6 ev, 3.4 ev, and 4.0 ev which shift under pressure toward higher energy, the pressure coefficients being $8.0 \times 10^{-6} \frac{ev}{bar}$, $6.4 \times 10^{-6} \frac{ev}{bar}$, and $6.7 \times 10^{-6} \frac{ev}{bar}$, respectively.

Figure 1 shows the pressure dependence of the 1.6 ev peak. As pressure is increased there is a linear shift of the reflection peak toward higher energies (shorter wavelength). The 3.4 ev peak and the 4.0 ev peak show a similar pressure dependence.



Important information can also be obtained from resistivity measurements under pressure. Such measurements have given evidence of the existence of several conduction band minima in silicon and have indicated that similar minima may be expected in CdS. Such information throws new light on the energy band structure of these solids. This, in turn, helps to predict its other electrical properties and its radiative properties and so to indicate its suitability for Air Force applications. All of these properties depend on the structure of the crystal and vary radically with its imperfections and impurities.

Eventually, it is hoped that, by proper selection of the host material and careful control of the impurities, it will be possible to grow crystals which possess the properties required for a wide variety of applications.

birth order and capacity for leadership

Dr. CHARLES E. HUTCHINSON Behavioral Sciences Division (AFOSR)

Dr. Ewart Smith, AFOSR contractor, of Serendipity Associates, has extended our knowledge in regard to the relationship between a person's order of birth within the family and the characteristics which influence his ability and inclination to assume leadership responsibility. Dr. Smith has utilized information on order of birth in analysing data drawn from a study of ten small fire engine companies and ten large fire engine companies in a major metropolitan area. The small companies had a captain and five men per crew; the large firehouses had a double company, i.e., two captains and two crews averaging eleven firemen per crew.

On the basis of previous experimentation it was hypothesized that first-born persons place more reliance on the judgments and opinions of others, as a means of solving problems. They are more dependent on others for approval and, therefore, solicit ideas and conform to the wishes of other group members to a greater extent than later-born persons. It was postulated that the tendency of first-borns to affiliate and interact more frequently with their fellows would be more evident in larger and more complex situations. The interactional skills developed by first-borns should lead to their use of group interaction to achieve solutions to problems and in their movement toward positions of leadership in the groups to which they belong.

These considerations led to the statement of the following hypotheses:

1. First-born subjects will rank lower than later-borns on personality measure of self-confidence.

2. First-born subjects will rank higher than later-borns in:

   a. Conformity in their group.

   b. Task performance in a group situation under time pressure.

   c. Perception of the social structure of their group.

   d. Leadership status in their group.

3. The relationships hypothesized linking birth order with social behavior and group task efficiency will be stronger in larger

more complex groups than in smaller, simpler groups.

The experiments performed by Dr. Smith utilized 165 firemen who were willing and eager to contribute their time to the investigation of problems of team, crew, and work unit efficiency.

The first group task was to discuss the following question for fifteen minutes: "You are to be marooned on a desert island with no immediate hope of rescue. You are allowed to take only three things. What will you choose to take?" This problem was chosen because its ambiguity would stimulate a good discussion.

The second task was a Horse Trading Problem which has been used previously as a measure of team efficiency. "A man bought a horse for $60.00 and sold it for $70.00. Then he bought it back for $80.00 and again sold it for $90.00. How much money does he make in the horse trading business?"

The subjects gave an individual prediscussion answer to each problem preceding group discussion. Individual post-discussion answers were elicited after the discussion period.

The results of the experiments confirmed the hypotheses in all cases except with regard to the performance of leaders in the small firehouses; and even in this case it was predicted that the effects of birth-order would be less evident, which was the case.

It is notable that the first-born were average in performance in their pre-discussion solutions to problems; but they exceeded the group norms in their responses after the problems were discussed.

The experimental confirmation of the positive relationship of the first-born position with leadership traits, leadership behaviors and actual leadership status is an important step in developing a better theory of leadership. We are beginning to identify the personal needs which impel some people to assume leadership. While this research does not supply a single dependable measure for the identification of leaders or the assignment of personnel to leadership functions, it will help in the development of instruments which assess the qualities and needs of effective leaders and permits us to recognize some of the developmental circumstances that prepare persons for leadership. The utility to the Air Force of a program which will improve methods for the selection and development of leaders is self-evident.

X-RADIATION SOURCE DISCOVERED

Research Instrumentation Laboratory (AFCRL)

An unsuspected source of X-radiation from deep within our galaxy has been discovered following a recent experiment conducted by AFCRL. The discovery was the result of a rocket experiment conducted on 18 June designed to measure X-rays emanating from the moon.

The Aerobee rocket fired from White Sands Missile Range in New Mexico carried X-ray sensors to a peak altitude of 140 miles. Data was telemetered back from the X-ray sensors during the flight, together with optical and magnetic data concerning the rocket orientation. Through the study of X-radiation from the moon, which is caused by the bombardment of its surface by solar radiation, AFCRL scientists hope eventually to be able to learn something of the composition of lunar surface materials.

The X-rays expected from the moon were, however, blanketed by a much stronger source some 30 degrees west of the position of the moon at the time the measurements were made. The source of the radiation was in the general vicinity of the constellation Scorpius. Analysis of the data from the sensors indicates that the radiation is in the form of soft X-rays that do not penetrate the atmosphere below 50 miles from the earth's surface.

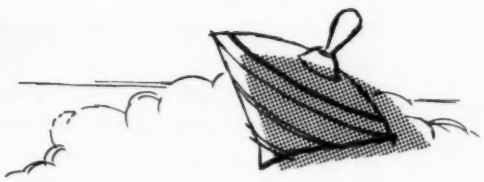
Dr. John W. Salisbury of AFCRL, who was in charge of the experiment, and contractor personnel of the American Science and Engineering who worked with Dr. Salisbury delayed the announcement

of their discovery until they were completely satisfied that the data on the unsuspected X-ray source was not the fault of the instrumentation.

It is not believed that there is any radiation source within our solar system to account for the observed data in the direction of Scorpius. This region of the sky is close to the center of our galaxy. The data also seem to indicate that the sensors may have detected a second X-ray source on the galactic rim.

A second rocket flight is now planned for October of this year to varify the results of the initial experiment. If the results are confirmed, it may be supposed that a distinct sub-division of radio astronomy will have opened -- one concerned with the mapping of X-radiation sources throughout the sky.

PROJECT SKY TOP



Research Instrumentation Laboratory (AFCRL)

Near infrared spectral observations of the moon were obtained in recent series of balloon telescope experiments high over the Southwestern United States.

Called project SKYTOP, a balloon borne Cassegrain telescope was successfully launched Wednesday, September 12 from Artesia, New Mexico reaching an altitude of about 86,000 feet. The launching was conducted by a team from AFCRL. Carried along on the 850 pound payload, in addition to the 12-inch Cassegrain telescope, was an interferometer spectrometer to take spectra of both the moon and the planet Venus. Instrumentation was designed by Roger A. Van Tassel of AFCRL.

Other information obtained on this initial flight concerned the amount of water vapor which was present in the thin atmosphere above the balloon gondola. The instrumented gondola is stabilized by a gyromechanism designed for AFCRL under contract by Tufts University.

A third objective of the flight was to obtain information required to measure the amount of different gases in the upper atmosphere of Venus. An instrumentation failure prevented the telescope from orienting on the earth's "sister planet" for a sufficient length of time.

NEW 150 FOOT RADIO TELESCOPE

SPACE PHYSICS LABORATORY (AFCRL)

A 150 foot radio telescope, now under construction at Sagamore Hill Observatory in Hamilton, Mass., is scheduled for operation early next year. When completed, the telescope will be one of the three largest radio telescopes in the U.S. The other telescopes, also of 150 feet, are operated by Stanford University in Palo Alto, California, and NRL in Chesapeake Beach, Maryland.

In September, the huge preassembled parabolic antenna was lifted to its mounting, a major milestone in the construction. The radio telescope will provide full horizontal scan. The hemispherical coverage, the large collecting area and deep space probe tracking capabilities will make it an extremely potent instrument for radio astronomy, propagation and detection research. When used with AFCRL's 84 foot radio telescope at the AFCRL radio observatory, the 150 foot telescope will give the AFCRL scientists an interferometer of extremely high resolution.

A large number of programs are planned for the antenna when it is placed in operation. Radiations from planets -- black body, synchrotron and burst -- will be studied to determine planetary atmospheres, as well as the mechanism causing radiation from planets. The study of Jupiter radiation, in particular, may provide information on our atmosphere, on the solar corpuscular stream, and on solar storms. All these studies have a bearing on communication and space navigation.

Studies of the aurora by means of radio star scintillation and absorption -- which have been in progress for several years using the 84 foot telescope -- will be expanded. With a detection area twice that of the 84 foot telescope, fainter noise sources can be detected.

Although precision tracking of deep space probes is provided for in the design of the antenna, such tracking will not be carried out initially due to limitations on funds for installing such tracking equipment.

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